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DETERMINATION OF FARES: PRICING THEORY AND ECONOMIC EFFICIENCY*

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The primary purpose of this presentation is to describe the concept of economic efficiency, its application to the pricing of air transport services, and its relevance as a policy objective. The first two sections discuss economic efficiency in general terms, whereas the third applies this norm to several airline pricing problems. The final section emphasizes the importance of industry behavior as a parameter in policy analysis.

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I. The Nature and Relevance of Economic Efficiency

A market is said to be "efficient" (in economic terms) when there is no other feasible means of production, no other combinations of qualities and quantities of outputs, and no other distribution of outputs which would make actual and potential producers and consumers as a group better off. If for some reason a market is not efficient, then by definition there exists some change which could improve the economic "welfare" of the market's participants: that is, there are potential modifications in production and/or distribution which could increase the utility (or "enjoyment") of at least one consumer (and/or producer) without decreasing the utility of anyone else.

More specifically, economic efficiency in airline service means that, given production and cost relationships, the quality and quantity of service output is one which satisfies consumers (and furthermore compensates producers) as well as any other. If the airline market is not efficient, then on balance someone could gain from a change. For example, airline customers as a group might prefer less quality and a commensurate lower fare (the lower quality requiring less cost and thus profits -- or return to carrier investment -- remaining unchanged). Or, carriers might be able to improve the existing production process, thus raising profits, increasing service quality, and/or lowering fares.

Of course, economic efficiency may not be the only rational public policy objective of an industry such as the airlines. In particular, for over 30 years it has been public policy to consider other goals in commercial aviation,

including: (a) "the promotion, encouragement, and development of civil aeronautics," (b) "the promotion of safety in air commerce," and (c) meeting "the present and future needs of the foreign and domestic commerce of the United States, of the Postal Service, and of the national defense."[1] While generally these and other goals mentioned in the Civil Aeronautics Board's "Declaration of Policy" are at least compatible with economic efficiency, depending on one's interpretation, in extreme form they can become overriding. For example, an efficient service is a reasonably safe one, but to ". . . assure the highest degree of safety . . . " (emphasis mine) would mean no service at all. Moreover, an efficient airline market is one which "promotes and encourages" air service to the extent consistent with optimizing resource use, but promotion beyond that means a less efficient market. Finally, to tailor air service to the special dictates of the Postal Service (PS) and/or the Department of Defense (DOD) probably would mean significant efficiency losses. However, provided PS and DOD "demands" for air service are weighed like those of other users, economic efficiency may obtain.[2]

There are many other public policy goals for the airline industry that could be mentioned. For example, the stability of rates and service. As we

1. Section 102 of the Federal Aviation Act of 1958.
2. Other goals implied by Section 102 of the FA Act likewise, depending on interpretation, are at least consistent with economic efficiency. Examples include: (a) recognition and preservation of inherent advantages of air transport, (b) coordination of services, (c) competition, (d) sound economic conditions, (e) adequate, economical and efficient service, (f) reasonable charges, (g) absence of price discrimination, and (h) limitations on predatory competition.

shall see below, for the market mechanism to function properly, prices (and service) will change from one time period to the next; thus, to some extent, "stability" may conflict with economic efficiency. Another role the industry conceivably may take is furthering the economic development of sparsely populated regions of the country. While undoubtedly this was a successful role for the railroads in developing the West, there is little hard evidence that commercial air service has a significant impact on community development, and, even if it did, one could speculate that development in one area is at the sacrifice of another. It would appear therefore that an undue emphasis on an economic development role for the airlines can conflict with economic efficiency.

Finally, another, very important public policy goal is "equity." For example, the institution of charging children less than adults is so ingrained that to suggest something different ruffles most people's sensitivities. Yet, from an economic efficiency standpoint (vis-à-vis profit or revenue maximizing price discrimination) there is little or no "justification" for children's discounts except in extraordinary circumstances. Another example, which incidentally, shows changing attitudes toward equity, is airline discounts for "youth" and the elderly. Because of backlash to student agitation in the late 1960's, people generally have become less inclined toward permitting youth-fare discounts, whereas discounts for the elderly are more in favor. However, a special discount for businessmen, aged 30-40, would doubtless be strongly opposed.

214

In summary, achieving economic efficiency in a market would appear to be a worthwhile, if not paramount, objective. There are many other public policy goals for the airlines, and for the most part these are at least consistent with economic efficiency, depending, of course, on one's interpretation. However, in some cases economic efficiency cannot obtain if certain other goals are given too great a weight. In light of this, perhaps the most important role of an economist is to indicate something of the economic efficiency "costs" of pursuing non-economic objectives.

II. Optimal Pricing, Quantity, and Service Quality

If we can assume that other industries are characterized by economic efficiency, then we may perform a "partial analysis" on a single industry such as the airlines. If this assumption does not hold, then one may have to resort to that analytical framework called the "economics of the second best."[1] For the purposes of this presentation we shall assume that economic efficiency does obtain elsewhere and further that there are no real (as opposed to pecuniary) externalities. In such a setting the prices paid for resources attracted into the industry in question reflect the true opportunity costs of their use elsewhere. For example, the price paid by the airlines for an aircraft reflects the value of those resources used in making the aircraft (labor, working capital, metal, etc.) had they been utilized in producing something

1. Cf., R.G. Lipsey and Kelvin Lancaster, "The General Theory of the Second Best," Review of Economic Studies, Vol. 24, No. 1 (1956-1957).

else (e.g., automobiles). By assuming that there are no externalities, we rule out changes in air service having any positive or negative impact on the rest of the economy not transmitted through the price mechanism. For example, increased air travel may lessen auto travel and thus (for a time at least) lower the value of General Motors stock, reduce the rate of advance in United Auto Workers' incomes, and decrease the pay received by executives with special expertise in auto production and sales. This, however, is a pecuniary externality, and has no effect on optimal resource allocation. On the other hand, increased air travel may augment air pollution over auto plants and raise costs of production. This is an example of a real externality, but for the moment we presume that these are unimportant.

Technical Efficiency

One requirement for economic efficiency in any industry is "technical efficiency," and by that we mean achieving any output at lowest cost.[1] Given a production function of the form

$$X = f(a, b, c, \dots), \tag{1}$$

there is a least-cost combination of inputs a, b, c, etc. which for any level (and quality) of output X', yields the lowest total cost to the firm. This technically efficient combination, of course, depends on the nature of the

1. This distinction between technical efficiency and "allocative efficiency" is somewhat arbitrary since the well-known efficiency conditions for production are closely akin to the allocative efficiency conditions in consumption. Nevertheless, it is a useful distinction and we will adopt it in this presentation.

production function and the prices paid for the inputs.[1] In a manner of speaking, then, given resource input costs and given equation (1), there is a (total) cost function which gives the lowest feasible cost for any level of output:

$$C = g(X). \tag{2}$$

This question of technical efficiency and the lowest-cost function may be visualized by referring to Figure 1. The average cost (i.e., cost per unit) curve labelled AC* is the technically efficient one, since all others (e.g., AC' and AC") have a higher average (and total) cost for each rate of output (in this case taken to be available seat miles per year).

Of course, an airline produces many "outputs" (service between different city pairs, different "classes" of service, etc.), so really it is more accurate to speak of a production function of many outputs as well as many inputs. In implicit form this can be written as

$$h(X_1, X_2, \ldots, X_n, a, b, c, \ldots) = 0, \tag{3}$$

where X_1, X_2, etc., are the various outputs. The technically efficient cost equation then becomes,

$$C = l(X_1, X_2, \ldots X_n). \tag{4}$$

This, of course, means that for any combination of outputs, X_1, X_2, etc., there is a least-cost means of production.

1. The necessary condition is that the ratio of marginal productivity to input price be the same for all inputs. Cf., James M. Henderson and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach (New York: McGraw-Hill Book Company, 1958), Chapter 3.

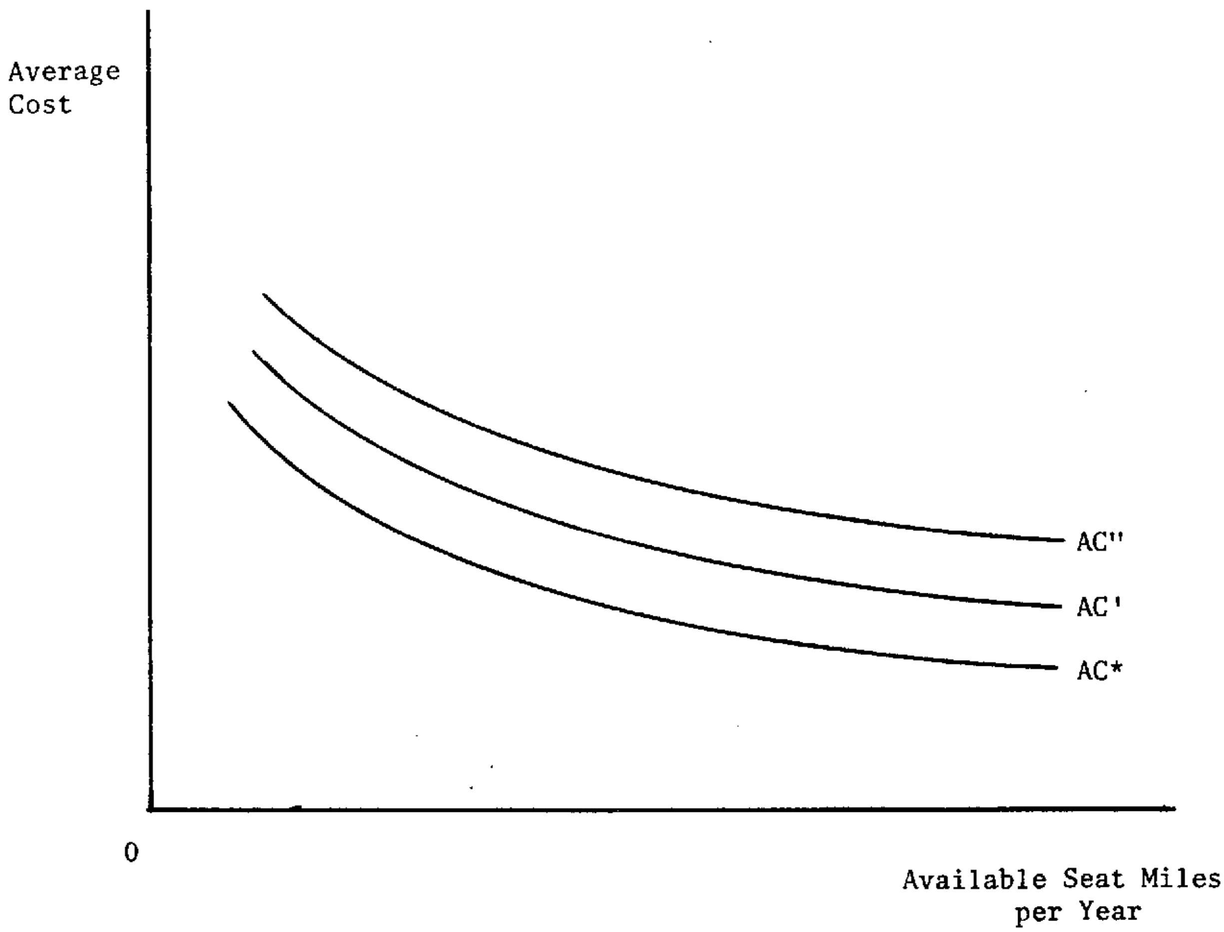

Figure 1

Allocative Efficiency

So far we have talked about what may be termed the "supply side." Equally important is the "demand side." That is, presuming that all outputs will be produced at lowest total cost, what are the appropriate amounts of each output and what is their optimal distribution? This is the basic purview of what economists term "allocative efficiency."

It should be obvious that we are trying to maximize something. What we are trying to maximize is the collective "economic welfare" of producers and consumers. Producer welfare is straightforward -- profits. These are net revenues exceeding a normal return on investment. The economic welfare of consumers is a bit more difficult to define. In essence it is the excess of what they would be willing to pay for the service over what they actually do pay. Obviously consumers will increase their rate of purchase of any service as price is lowered. This is the so-called "law of demand." Stated another way, the maximum price consumers would pay for any incremental increase in total output is given by the inverse of the demand relation, or,

$$P_i = P_i(X_i), \tag{5}$$

where P_i is the demand price for output X_i. Consumers' total utility for consumption of any rate of X_i can be approximated by the area under relation (5). Subtracting total revenues paid, (net) consumer welfare is given by:

$$CW = \sum_{i=1}^{n} \left[\int_0^{X_i} P_i(X_i)dX_i - P_i(X_i) \cdot X_i\right]. \tag{6}$$

In analogous fashion, the welfare of producers (i.e., profit) is defined as:

$$\text{(7)} \qquad PW = \sum_{i=1}^{n} P_i(X_i) \cdot X_i - C(X_1, X_2, \ldots, X_n).$$

We are now in a position to maximize total economic welfare, weighting the welfare of producers and consumers equally.[1] Adding (6) and (7) and simplifying,[2] we have:

$$\text{(8)} \qquad TW = \sum_{i=1}^{n} \int_{o}^{X_1} P_i(X_i) dX_i - C(X_1, X_2, \ldots, X_n).$$

The first-order conditions for maximizing (8) are:[3]

$$\text{(9)} \qquad P_i(X_i) - \partial C / \partial X_i = 0$$

$$i = 1, 2, \ldots, n.$$

This merely states that resources are allocated efficiently when the price of each output $[P_i(X_i)]$ equals the marginal cost of producing that rate of output $(\partial C / \partial X_i)$.

We may verbalize this result as follows. Marginal cost reflects the additional cost of production associated with increasing output by that unit. Demand price is a measure of the value consumers place on the marginal unit. Because demand price decreases with extra units, an output less than where price equals marginal cost means that some consumer values additional output more than the extra cost of production. From a societal point of view, output in that (sub)market is thus suboptimal. There exists a potential for a buyer to compensate a producer for the extra costs incurred and still be better off.

1. Other weights, of course, could be used.
2. The total revenue term cancels out.
3. We shall assume without further comment that second-order conditions obtain.

On the other hand, if the rate of any output exceeds that commensurate with a marginal price equal to marginal cost, then output is "superoptimal" and allocative efficiency does not obtain. In such a case, consumers value the marginal unit less than the associated increment of cost. Alternatively, a reduction in output would mean a savings in cost in excess of the lost value to consumers. Such reasoning thus leads to the conclusion that price must equal marginal cost in each market for allocative efficiency to obtain. [1]

In order to achieve allocative efficiency, it is essential that there be no arbitrary limitations on consumer "eligibility" for particular markets. That is, all consumers must have access to each type of output. Arbitrarily making one group of consumers ineligible and having to enforce such a restraint means that some consumers in the group discriminated against would willingly pay more than the marginal cost of output and thus economic efficiency does not obtain. A similar case is where different consumer groups pay different prices for the <u>same</u> output. To have to enforce such a partition means that some in the group discriminated against would willingly exchange money (i.e., a lower price) for the output consumed by the group most favored. If the favored group obtains output below marginal cost this still means an efficiency loss, for their consumption (at the margin) is valued less than the associated (marginal) cost of production.

1. We note in passing that generally the production of airline services is characterized by constant returns to scale for relevant ranges of output. [See "Testimony of James C. Miller III," CAB Docket 21866-7, DOT-T-1 (August 25, 1970) and the references cited therein.] Thus "marginal cost pricing" would mean total revenues sufficient to cover total costs.

Optimal Quality

Another allocative efficiency type question relates to the optimal quality of service. (Thus far we have assumed that quality is given.) For example, as George Douglas has shown, lower average load factors mean that flights are more frequent and that the probability of getting a seat on the desired flight is greater. But lower load factors, like other service amenities (such as speedy baggage claim, more elegant on-board accommodations, and more personal attention) can be achieved only at greater cost to the firm and thus to the consumer. From the individual consumer's viewpoint, the problem is basically one of "trading off" the (marginal) value of increased quality with the associated increase in cost. The important thing to consider is that service quality does matter.[1] If the "wrong" quality of service is provided, then allocative efficiency does not obtain any more than efficiency obtains when prices are unequal to marginal costs.

The (conceptual) determination of optimal service quality is illustrated in Figure 2. Quality is measured on the horizontal axis in units and on a scale

1. The relevance of service quality can be seen with the model sketched out as follows. Individual i's utility is defined by $U_i=U_i(X, Q, W,)$, where X= quantity of output, Q=quality of output, W=work expended, and where $\partial U_i/\partial X>0$, $\partial U_i/\partial Q>0$, and $\partial U_i/\partial W<0$. The perfectly competitive supply total cost of output is defined as $C=C(X, Q,)$, where $\partial C/\partial X>0$ and $\partial C/\partial Q>0$. Finally, total income (for spending on output) is the wage rate r times work expended, W. The maximization problem then resolves into Max: $Z=U_i(X, Q, W) - \lambda[C(X, Q)-rW]$. Not counting the budget constraint, the first-order conditions (second-order assumed to hold) come down to: $(\partial U_i/\partial X)/(\partial C/\partial X) = (\partial U_i/\partial Q)/(\partial C/\partial Q) = (\partial U_i/\partial W)/(-r)$, which means that the ratios of marginal utilities of output quantity, output quality, and work expended to their respective "costs" are equal.

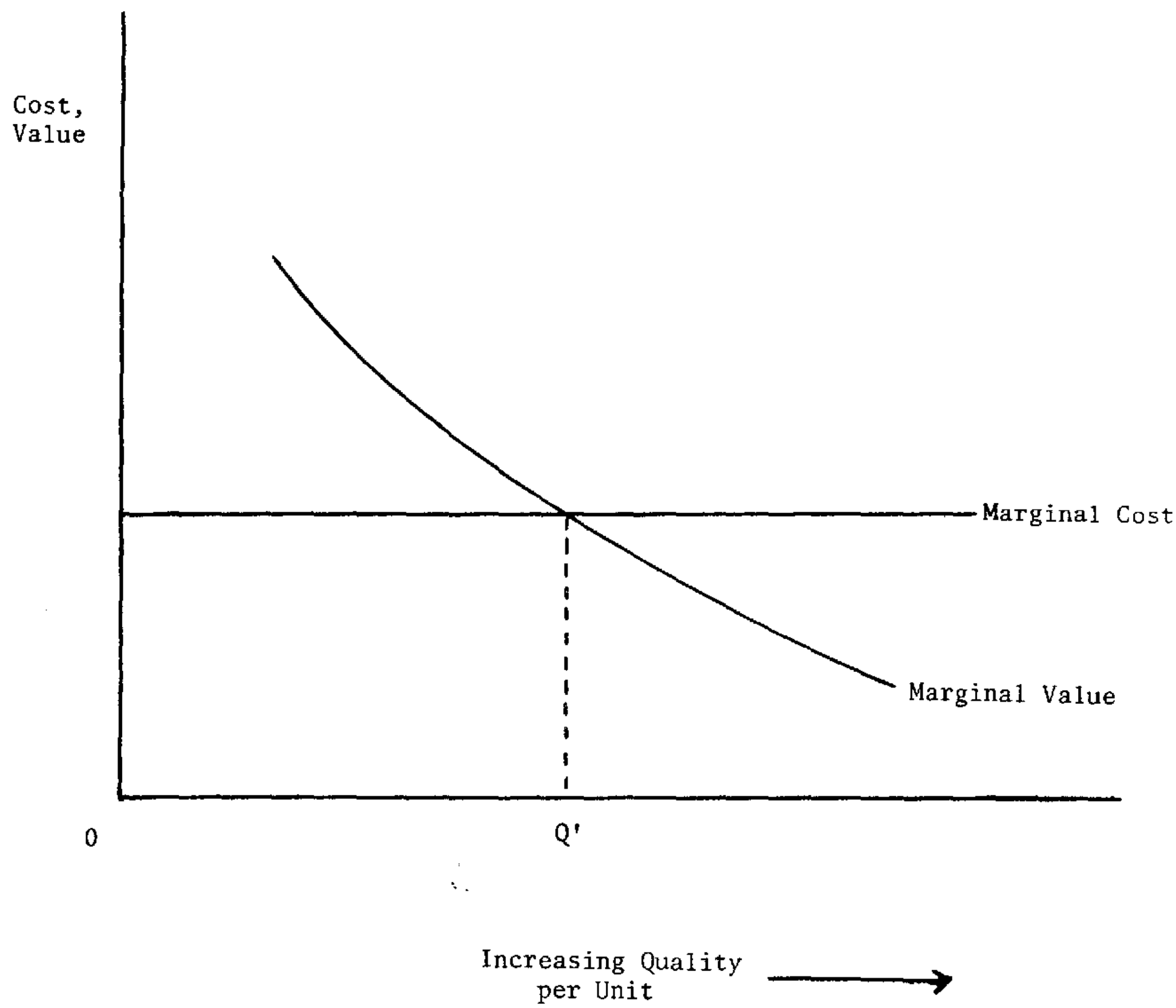
Cost,
Value
Marginal Cost
Marginal Value
0
Q'
Increasing Quality
per Unit

Figure 2

which is commensurate with equal outlays for successive quality increases. While higher quality, of course, is desirable, one presumes that after a point the (extra) value of increased quality becomes less and less. Thus, for quality less than Q', the individual in question values increased quality more than the commensurate increase in per-unit cost. Past Q', greater quality is still desirable, but of less value than the extra cost. Thus, allocative efficiency requires that the quality of service be at Q' and in addition the price of service be equal to marginal cost.

III. Applications to Airline Pricing and Resource Allocation

Having set out these general rules for efficient resource allocation, it is important to understand that their application to transportation industries, specifically the airlines, is no easy task. The pricing of airline service is complicated by a number of very important characteristics of air transport cost and demand.

On the cost side there are indivisibilities in production. Not only do aircraft come in discrete units, but what is probably more important, their seat capacity is not subject to instantaneous change. Even if it were possible to select the "best" aircraft (in the sense of seating capacity) for a set of city-pair markets, because there are variations in density of travel among such cities and because there are economies in reducing the number of different aircraft types employed, one normally would expect that on some routes either

aircraft would fly with some empty seats and/or passengers would be left at the gate unless there were sufficient pricing flexibility to ration off excess demand and/or fill empty seats. Moreover, as Douglas has described, demand is not "certain," but stochastic. Because of this characteristic there will be additional instances of excess demand for seats on the one hand, and excess capacity (i.e., aircraft not fully loaded) on the other.

Another characteristic of airline costs is that seat-mile costs for a given trip distance fall with larger aircraft size. This accounts for the propensity for users of air service to consolidate their demands. While some high-salaried executives may indeed depart via a personal turbojet aircraft when and where they desire, the strong scale economies associated with aircraft size make it desirable for most travelers to aggregate their preferred departure points (and destinations) and their preferred departure (and arrival) times to common ones.

On the demand side, users of airline services place some value on the reliability and stability of rates and service. Since information is not perfect and costs of coordination are not negligible, the convention of scheduled service at assured fares has emerged. If the information and adjustment processes were without cost, then the efficient solution would require holding up departures until a full load of passengers could be generated (at a price commensurate with 100 percent load factors). Or, as William Vickery has suggested, price could be varied instantaneously so as to fill the aircraft by the precise time

of departure.[1] Actually, neither scheme is optimal simply because users of air service value certainty and wish to save on information costs.[2]

A related characteristic of demand is that because of the emerging convention of scheduled service, the presence of excess capacity is highly valued. (This was described by George Douglas in the previous presentation.) If average load factors are 50 percent rather than 75 percent, then the probability of a user's being able to secure passage on the scheduled flight of his choice is higher. Also, for given aircraft capacities, a lower average load factor means a greater frequency of service and thus a higher probability that a flight is scheduled reasonably close to the user's most desired time of departure.

As noted before, however, excess capacity has its costs, since users must pay for it if total costs are to be covered. Thus, the relevant decision is not whether to have excess capacity, but rather how much is optimal. On an aggregate level this depends on users' perception of the marginal values and marginal costs of excess capacity.

There are a number of other economic efficiency questions having to do with excess capacity, an important one being the argument for discriminatory discount fares.[3] Essentially, the proposition is as follows: given that the

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1. William Vickery, "Responsive Pricing of Public Utility Services," The Bell Journal of Economics and Management Science (Spring 1971), pp. 341-2.
2. Compare the advantage of having readily-available information on flight prices and departure times with a need to monitor constantly changing flight-time and price alternatives.
3. These include youth and military discounts, discounts for children, etc.

airlines have excess capacity, why not give a price break to new, previously untapped markets; if these consumers pay anything in excess of "marginal" costs (presumed to be very low), then existing passengers too stand to benefit since this means their fare can be lowered. This argument, while intuitively appealing, fails to recognize the essential role of excess capacity in the quality of service and further ignores relevant opportunity cost concepts.

If excess capacity is one dimension of service quality, then the addition of reserved-seat discount passengers lowers service quality for "regular" passengers. In addition to the lower probability of obtaining a seat on the desired flight, there is the disadvantage of sharing flight attendants with more passengers, plus the extra crowding on-board and greater time taken in aircraft ingress and egress.

More relevant, however, is the fact that the real (i.e., opportunity) cost of adding a discount passenger is the value of the service to the (marginal) potential regular passenger who does not fly because the discount is not made available generally. And because the real cost of the extra service to the (marginal) discount passenger exceeds the fare he pays, there are allocative efficiency losses.

There are two relevant modifications to this analysis that should be mentioned, both having to do with the total volume of traffic under the two pricing schemes. If under discriminatory discount fares the total volume of traffic at any point in time is greater than with a non-discriminatory, lower price (or alternatively lowering the regular price won't "fill" existing aircraft

as effectively as employing discriminatory fares), then this is simply an indication that total airline capacity is excessive. On the other hand, as George Douglas has shown, in very small markets the increase in service quality (via greater frequency, lower seat costs of larger aircraft, etc.) arising out of increased total traffic volume with discounts (as opposed to lower normal fares) provides some justification for discount fares, at least in those markets. However, the optimal fare differential under such circumstances is likely to be very small.[1]

Excess capacity is also related to seating density, another obvious quality parameter. For a given flight, the greater the seating density the greater is quality in terms of seat availability, but the less is seating comfort. Of course, passengers differ in their preferences, but it would appear likely that after some point the typical user would prefer to convert some excess capacity (in the form of extra seats) into less dense seating. Moreover, since for a given rate of travel between city pairs the cost of excess capacity is greater for long-haul flights than for short-haul, one would expect optimal load factors and seating densities to be higher for long-distance travel. Finally, since for a given length of haul the marginal value of excess capacity (in terms of reducing delay time) is greater for lower density markets, one would expect optimal load factors and seating densities to be higher the greater the total volume of traffic.[2]

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1. George W. Douglas, "Price Discrimination and Scale Economies in Scheduled Air Transportation" (Chapel Hill: processed, 1971).
2. Also, see George Douglas' presentation.

The institutions surrounding commercial aviation raise several more interesting types of efficiency problems. For example, since under current arrangements the non-fulfillment of a reservation is costless, for a typical flight more reservations are made than passengers show up. This, in turn, leads carriers to "overbook" flights, relying on "no-shows" to yield enough extra seats. Occasionally, however, the number of showing reserved-seat passengers exceeds the flight's capacity. The U.S. Civil Aeronautics Board (CAB) now fines airlines for this practice, but obviously, given the institution of free reservations, some overbooking is optimal. In fact, the optimal fine is one which causes airlines to overbook just to the point that the number of additional reserved passengers left at the gate just offsets the number of extra passengers who could have been accommodated in seats made available by no-show reservation passengers.

The subject of airline safety is much too broad to receive adequate attention here. However, it is important to note that safety has its "costs." Its benefit, of course, is a reduced probability of a serious or perhaps fatal accident. Depending on one's valuation of human life and suffering, the optimal expenditure on safety is where the expected value reduction in accident "costs" just equals the marginal cost of this (increased) safety provision.[1]

Another type of allocation problem arises in connection with the efficient pricing of different outputs on the same aircraft flight. As between first-class

1. For an interesting discussion see Thomas C. Shelling, "The Life You Save May Be Your Own," in Samuel B. Chase, Jr., (ed.), Problems in Public Expenditure Analysis (Washington: The Brookings Institution, 1968).

and coach service, it is important to recognize that the opportunity cost of first-class space is the eliminated coach space; and vice-versa.[1] In effect, except for the extremely short run, first-class and coach space are common costs (i.e., their proportions may be easily varied by moving the bulkhead and changing a few seats). Keeping in mind that first-class passengers receive extra service amenities in the form of more personalized stewardess services (fewer passengers per stewardess), more expensive meals, etc., that they exit the aircraft before coach class (and thus considering opportunity cost their cost is higher), that the space between rows of seats is greater than in coach class, and that load factors in first class are usually lower than in coach, a good rule of thumb is that first-class accommodations should be priced at least 50 percent higher than coach, since first class has four seats abreast whereas coach class typically has six.[2]

The optimal relationship between passenger and cargo prices is more difficult to determine. The problem is that while the ratio of passenger vs. cargo space on a "combination" aircraft is variable at the aircraft manufacturing

1. Aircraft are much more commonly space-constrained as opposed to weight-constrained. Thus, space is the relevant scarce resource, although obviously weight constrained cases are important.
2. It is worth noting that in many cases what a first-class passenger buys is not so much more luxurious accommodations but simply a confirmed space. That is, since load factors average much lower in first class, peak-hour accommodations are typically rationed by the first-class fare. Also, obviously people pay extra for the ability to obtain a reservation "at the last minute." Both roles for first class could be handled more efficiently by peak-load-pricing and perhaps by reserving a block of standard seats for last-minute sales (at a higher price).

stage, once an aircraft has been produced it is most difficult to reallocate space.[1] Thus, in the long run, cargo and passenger space are common products; in the strict short run they are joint products. As a forthcoming paper by the author suggests, an appropriate pricing rule is to charge "belly freight," a price equal to the cost of carrying such freight (at comparable service quality) in all-freight aircraft.[2]

IV. The Relevance of Industry Behavior

Many pricing problems in the airlines must be considered within the context of industry behavior. By "industry behavior," we mean the response pattern that describes industry "competition." Briefly, as DeVany, Douglas, Eads, Jordan, Yance, and I have argued, the domestic airline industry can be characterized as a non-price competing cartel.[3] Prices are given, being regulated by the CAB. Carriers then "compete" (or rival) in non-price (i.e., quality) dimensions, primarily the extent of excess capacity. Our operational

1. Almost all commonly used passenger aircraft have cargo space in excess of that required for passenger baggage.
2. See "Cargo Pricing and the Configuration of Combination Aircraft," Journal of Transport Economics and Policy (forthcoming).
3. See Arthur DeVany, "The Economics of Quality Competition: Theory and Evidence on Airline Flight Scheduling," unpublished (c. 1969); George W. Douglas, CAB Docket 21866-9, DOT-T-3 (May 17, 1971); George Eads, "Competition in the Domestic Trunk Airline Industry: Excessive or Insufficient?" (Washington: The Brookings Institution, forthcoming); William A. Jordan, Airline Regulation in America: Effects and Imperfections (Baltimore: Johns Hopkins Press, 1970); Joseph V. Yance, CAB Docket 21866-6, DOT-RT-1 (July 27, 1970); and James C. Miller III, CAB Docket 21866-6, DOT-T-1 (July 6, 1970).

hypothesis is that over time schedule frequency will adjust in individual (competitive) markets so that actual load factors approximate break-even (including a normal return on investment).[1]

To see that carriers have incentives which cause them to move in the direction of break-even load factors, consider first a situation where prevailing load factors are above break-even. In this disequilibrium situation, carriers will expand scheduling in hopes of making profits on extra flights. Load factors will fall. If on the other hand prevailing load factors are below break-even, carriers will be prompted to cut back on scheduling as a means of reducing losses. Load factors will rise.[2]

We may illustrate the importance of policy-makers' understanding industry behavior with three examples.

Cross-Subsidy by Length of Haul

For many years the CAB has fostered a policy of "cross-subsidizing" long-haul and short-haul markets. Essentially the argument is that fares

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1. Recently the CAB has recognized the applicability of this model to airline regulation, stating,

   > "It is indisputable that every fare level has a built-in load factor standard. We find, as DOT has stated, that the higher the fare level in relation to cost, the more capacity carriers will offer and the lower load factors will be; and, conversely, the lower the fare level, the less capacity carriers will operate and the higher load factors will be." (CAB Order 71-4-54, April 9, 1972, p. 23.)

2. This argument is often missed (and perhaps purposely obfuscated) by those placing especial emphasis on market share relationships. Douglas and I deal with this in our Brookings study (op. cit.).

cannot be raised to the level of average cost in short-haul markets since there would be "undue diversion" to alternative, competitive modes. Fares in long-hauls, however, should exceed costs, the long-haul profits thereby used to (cross-) subsidize losing short-haul business. The basic price-cost relationship by length of haul is illustrated (conceptually) in Figure 3.

"While this may work in theory, it doesn't work in practice." What happens is that because break-even load factors are high in short-haul markets, actual load factors also tend to be high. Because break-even load factors are low in long-haul markets, actual load factors also tend to be low. This is seen in Table 1. (N. B., load factors for very short-haul markets include many local service subsidized routes where because of the subsidy, break-even load factor is lower than otherwise.) Note particularly the monotonic decline in load factors past 500 miles.

In short, cross-subsidy is largely a fiction and it will continue to be as long as carriers are free to adjust capacity in response to prices and costs.

Pricing Strategies to Control Pollution

With increasing public concern over the "environmental impact" of economic activities, commercial airports have been singled out (somewhat unfairly) as a primary source of air and noise pollution. Much is being done by way of "retrofitting" old jet engines and redesign of new ones. However, this may be viewed as a longer-range solution and even under technology likely to materialize could not be expected to eliminate aircraft pollution entirely.

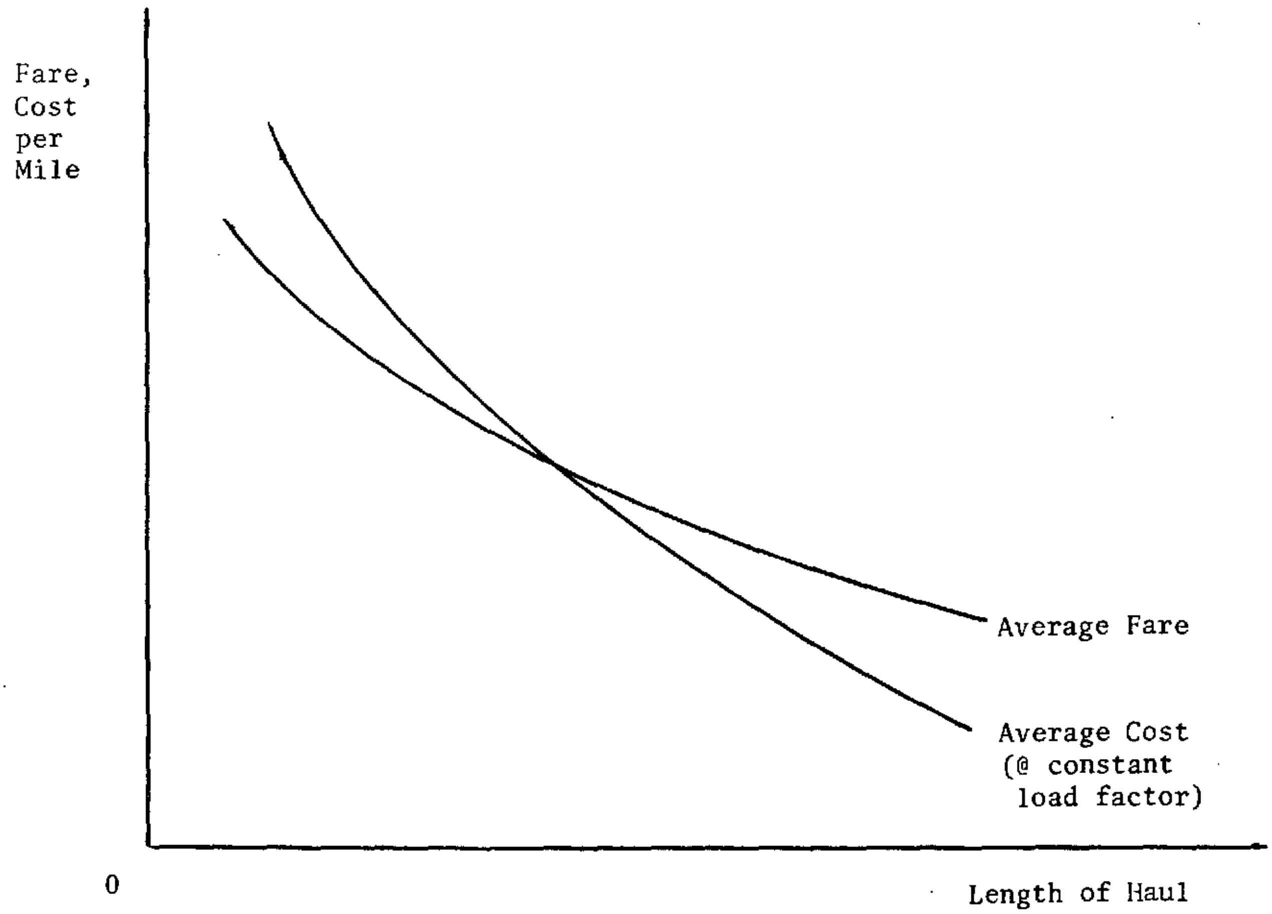
Fare,
Cost
per
Mile
Average Fare
Average Cost
(@ constant
load factor)
0
Length of Haul

Figure 3

234

Table 1: 1969 Coach Load Factors by Length of Haul

Miles	Load Factor	Miles	Load Factor
100	50.7	1,300	53.8
200	53.1	1,600	52.5
300	53.6	1,900	52.2
400	54.6	2,200	49.9
500	55.6	2,500	46.0
700	55.4	2,800	45.9
1,000	54.8	Average	50.0

Source: CAB Docket 21866-9, BC-4808.

235

Economists have often suggested using the price mechanism to "internalize" pollution costs and thus, _ceteris paribus_, bringing about a more efficient level of pollution output. We shall assume that pollution is a monotonic, increasing function of the number and size of aircraft making take-offs and landings, and thus, as a proxy, the narrow policy objective is to decrease the number of seats scheduled by commercial operators.

The industry behavioral model described in the previous section may be sketched out as follows. Quantity of air service demanded (_ex ante_ and supplied _ex post_) is a function of both price and the number of seats scheduled: $D = D(P, X)$. Average and marginal costs are of two kinds: first, those associated with passengers (C_d), and second, those related to seats (C_x).[1] Assuming constant returns to scale in both categories, the total cost function is given by $C = C_d D + C_x X$. Finally,

$$\pi = D(P - C_d) - C_x X = 0, \tag{10}$$

where π is profit, and any excess profit (or loss) "slack" is taken up by variations in X.

As discussed below, the important policy variables are P, C_d, and C_x. We wish to know their individual effects on X. Equation (10) may be differentiated to yield,

$$\frac{dX}{dP} = \frac{D[1+e_d(1-C_d/P)]}{C_x-(\partial D/\partial X)(P-C_d)}, \tag{11}$$

1. This corresponds generally to the conventional distinction between "direct" and "indirect" airline costs.

(12) $$\frac{dX}{dC_d} = \frac{-D}{C_x-(\partial D/\partial X)(P-C_d)}, \text{ and}$$

(13) $$\frac{dX}{dC_x} = \frac{-X}{C_x-(\partial D/\partial X)(P-C_d)},$$

where e_d is the price elasticity of demand. Also, we note that,

(14) $$dX = \frac{D[1+e_d(1-C_d/P)]dP-DdC_d}{C_x-(\partial D/\partial X)(P-C_d)}, \text{ and}$$

(15) $$\frac{\partial D}{\partial X} < \frac{D}{X}.$$

Equation (15) simply states a necessary condition for market equilibrium, namely that as carriers put on additional capacity, load factors fall (i.e., "marginal load factor" is less than average load factor). (Otherwise scheduling would increase without limit.)

Public policy to restrain aircraft pollution through market incentives may be initiated by two groups. First, the CAB may effectuate a change in the level of fares. For example, one presumes that a fare increase would have a depressing effect on aircraft pollution. (But read on!) Second, the local-government airport authority may impose some form of "user charges" to curtail total pollution output.[1] Let us consider the following alternatives: (1) a fare increase imposed by the CAB, (b) an increase in landing fees imposed by local authorities, (c) a "head tax" paid by passengers, (d) a head tax paid by the air carriers, and

1. Most major commercial airports are owned and operated by local governments. The exceptions include the two Washington, D.C., airports, National and Dulles, owned and operated by the Federal Government. (It has been proposed that these be sold to the highest bidder.) Some airports are privately owned and operated, the largest being Burbank, California.

(e) a head tax paid by the carriers where the CAB allows them to pass along the cost increase in the form of higher fares.[1]

From equation (11) we may determine that an increase in the price of air service will actually increase X if $e_d > -1$. The denominator of the right-hand side of (11) [and also of (12), (13), and (14)] is positive by reference to (10) and (15). The numerator is negative only when demand is sufficiently elastic that $e_d(1 - C_d/P) < -1$.[2] This is an important result, inasmuch as the CAB, at least, judges air travel demand to be inelastic.[3] If true, then a corollary of the above result is that the Board could bring about a reduction in pollution by lowering fares.

An increase in landing fees would be tantamount to an increase in C_x.[4] From equation (13) we see that the effect would be a reduction in X since the right-hand side is negative.

A head tax on passengers would be similar to an increase in fares, but the difference is decisive. Whether demand is elastic or inelastic, carriers' total revenue would be reduced (i.e., quantity demanded would fall because of the perceived higher price), and thus scheduling would have to contract.[5]

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1. Of course, there are other alternatives (e.g., flight quotas, price discrimination, etc.), but these are not considered here.
2. Roughly this would require that $e_d < -2$, since in practice $C_d/P \approx .5$.
3. The CAB has found demand elasticity to be -.7 (CAB Order 71-4-59, 71-4-60, April 9, 1971, p. 50.). While many researchers disagree with this assessment, few would maintain that $e_d < -2$.
4. Landing fees are typically in proportion to the gross weight of the aircraft.
5. The application of a head tax would mean an unambiguous decrease in D. Referring to equation (10), since $C_d < P$ and C_x is unchanged, X must decrease.

If the carriers pay the head tax, this would mean an increase in C_d. Since the right-hand side of equation (12) is negative, the result would be a diminution of X and thus a decrease in pollution.

Finally, a head tax paid by the carriers which is passed along in the form of higher fares would likewise have a depressing effect on X. Note that in this case $dP = dC_d$ in equation (14) Since $e_d < 0$, the numerator is always negative.

Thus, in one case what would seem like a straightforward policy action to control pollution (i.e., higher fares to choke off demand) would be likely to have the reverse result, owing to the industry behavior pattern that has developed under Federal regulation.

Pricing and the Demand for Aircraft

A related issue is the effect of airline pricing on the derived demand for aircraft. In other words, how would changes in fare levels (everything else equal) affect airlines' requirements for new aircraft?

First, it is notable that many economists and others have recommended that the airlines be "deregulated." Based on the available experience with a deregulated airline environment (e.g., the California intra-state market[1]), the presumption is that fares would fall substantially. Carriers generally oppose fare reductions, but with increasing pressure from charters and the imposition of the Board's higher load factor standards, prospects for significant fare reductions must be seriously considered.

1. On this see Jordan, ibid.

Anyway, the normal reaction to the fare-aircraft demand issue goes something like this: lower fares would mean greater travel and thus a greater demand for aircraft. However, it should be recognized that lower fares mean an increase in break-even load factor. The question is whether the rise in break-even load factor is more or less than sufficient to offset the increase in passenger demand.

The answer is given by equation (10), and this result comes as something of a surprise. That is, a decrease in fares (ceteris paribus) would likely curtail airlines' requirements for new aircraft. Given this result, I would expect Boeing, McDonnell-Douglas, Lockheed and even NASA to be ardent supporters of CAB regulation!

240